

A COMPARISON OF THE IMMEDIATE EFFECTS OF ECCENTRIC TRAINING VS. STATIC STRETCH ON HAMSTRING FLEXIBILITY IN HIGH SCHOOL AND COLLEGE ATHLETES

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ABSTRACT

Background. A pre-event static stretching program is often used to prepare an athlete for competition. Recent studies have suggested that static stretching may not be an effective method for stretching the muscle prior to competition.

Objective. The intent of this study was to compare the immediate effect of static stretching, eccentric training, and no stretching/training on hamstring flexibility in high school and college athletes.

Methods. Seventy-five athletes, with a mean age of 17.22 (+/- 1.30) were randomly assigned to one of three groups – thirty- second static stretch one time, an eccentric training protocol through a full range of motion, and a control group. All athletes had limited hamstring flexibility, defined as a 20° loss of knee extension measured with the femur held at 90° of hip flexion.

Results. A significant difference was indicated by follow up analysis between the control group (gain = -1.08°) and both the static stretch (gain = 5.05°) and the eccentric training group (gain = 9.48°). In addition, the gains in the eccentric training group were significantly greater than the static stretch group.

Discussion and Conclusion. The findings of this study reveal that one session of eccentrically training through a full range of motion improved hamstring flexibility better than the gains made by a static stretch group or a control group.

INTRODUCTION

Most experts consider aerobic conditioning, strength training, and flexibility to be the three key components of a conditioning program.¹⁻³ By definition, flexibility is the ability of a muscle to lengthen and allow one joint (or more than one joint in a series) to move through a range of motion, and the loss of flexibility is a decrease in the ability of a muscle to perform.⁴ Reduced injury risk,^{1,3} pain relief,⁵ and improved athletic performance^{6,7} are reasons provided for incorporating flexibility training into a training program.

Static stretching, defined as elongation of a muscle to tolerance and sustaining the position for a length of time,^{6,8} is considered the gold standard in flexibility training. Some authors have questioned the importance of using static stretching to help reduce injuries and to improve athletic performance.¹⁻³ Recent studies have found that static stretching is not an effective way to reduce injury rates,⁹⁻¹¹ and may actually inhibit athletic performance.¹² Murphy¹³ made a compelling argument against the use of static stretching. Although static stretching is often used as a part of preactivity preparation, Murphy¹³ argued that the nature of static stretching is passive and does nothing to warm a muscle; further, although the hamstring muscle is the most frequently stretched muscle, it is also the most commonly strained.

A better option for increasing flexibility, according to Murphy,¹³ would be an activity that is more dynamic by nature. Murphy,¹³ therefore, introduced what is referred to as “dynamic range of motion.” To dynamically stretch a muscle, the antagonist group is contracted thus allowing the agonist to elongate naturally in a relaxed state. The dynamic nature of the activity, in theory, would cause a warming effect in the muscle, and the mus-

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cle would be more pliable and accommodating to the stretch, leading to an increase in the flexibility of the muscle.

In contrast to the belief of Murphy,¹³ Bandy et al¹⁵ compared the flexibility gains made by subjects participating in a dynamic range of motion program with gains subjects achieved using a static stretching program. The gains achieved by the group in the static stretching program were greater than those achieved with dynamic range of motion.

More recently, Nelson and Bandy¹⁶ investigated a flexibility program which consisted of eccentrically training a muscle through a full range of motion. Previous literature suggests that most injuries occur in the eccentric phase of activity.⁹ For example, the hamstring muscles are most commonly injured when working eccentrically while decelerating or landing. Eccentrically training a muscle through a full range of motion, theoretically, could reduce injury rates, improve athletic performance, and improve flexibility. Nelson and Bandy¹⁶ compared the flexibility gains made over a six week period of time by a control group, a static stretch group, and a group who eccentrically trained the muscle through a full range of motion. The findings of the study were a significant increase in flexibility in the static stretch group (12.05°) and in the group who trained eccentrically through a full range of motion (12.79°) over the control group (a 1.17° change). The difference in the flexibility gained between the static stretch group and the eccentric training group was not significantly different. This study offers compelling evidence to incorporate eccentric training into any training program.

While it has been found that eccentrically training a muscle through a full range of motion will improve flexibility over a period of six weeks as well as static stretching, no study has been conducted to determine the immediate effects of one bout of eccentric training compared to one bout of static stretching and comparing both with a control. A pre-event stretching program is often used by coaches to prepare an individual for athletic competitions. Some of the goals of pre-event flexibility training program include decreasing the chances the individual will sustain an injury, warming the muscle, and improving the flexibility of the muscle in preparation for the activity. Theoretically, eccentric training will decrease injury rates and warm a muscle, but no study

has been performed to determine the effects a single bout of eccentric training has on flexibility. Therefore, the purpose of the study is to determine if one bout of eccentric training through a full range of motion will improve flexibility and to compare the results with one bout of static stretching and a control group.

METHODS

Subjects

Eighty-seven subjects were recruited on a voluntary basis to participate in the study. The authors felt attrition would be low given the design of the study. By recruiting eighty-seven subjects this ensured the study would have the appropriate number needed when complete. Subjects were high school football players at Texarkana, Arkansas High School and Liberty Eylau High School, and college baseball players at Texarkana Community College. Subjects over the age of 18 signed an informed consent form. Subjects under 18 years of age had a parent or guardian sign the informed consent form and the minor signed an informed assent form. This study was approved by the Institutional Review Board of the University of Central Arkansas.

Volunteers for the study had to meet three requirements. The first requirement was the test extremity must have had no impairment to the hip, knee, thigh, or the low back for the previous year. The second requirement was the test extremity had to exhibit hamstring tightness. A deficit of 20° from full knee extension with the hip at 90° was defined as tight hamstrings. The subjects were also all high school and college athletes between the ages of 15 and 21 years.

Equipment

A double-armed transparent plastic goniometer was used for measuring hamstring flexibility. The protractor portion of the goniometer was divided into one-degree increments. The goniometer arms were 12 inches in length. A bubble was removed from a carpenter's level and fixated to the goniometer to help ensure maintenance of the hip at a 90° angle.

Procedures

Measurement of hamstring flexibility was performed using the 90/90 test for hamstring flexibility described by Reese and Bandy.¹⁷ The subjects were positioned in supine with the hip and knee flexed to 90°. The

researchers palpated the lateral epicondyle of the femur and centered the goniometer over that landmark. The greater trochanter of the femur and the lateral malleolus of the tibia were marked. The goniometer was aligned with the lateral malleolus and the greater trochanter and centered over the lateral epicondyle. (Figure 1)

The markings on the goniometer were concealed with a piece of paper. While one researcher held the goniometer the other researcher moved the leg passively toward terminal extension. The point at which the researcher felt a firm resistance was defined as terminal extension. When the subject reached terminal extension the researcher holding the goniometer made sure proper alignment was maintained. An assisting examiner read and recorded the measurements on the blinded goniometer. Full hamstring flexibility was zero degrees on the goniometer. The subjects had no warm-up before data collection.

Since reliability had been established previously in the study by Nelson and Bandy,¹⁶ and the same researchers were performing the measurement, the reliability study was not replicated. A pretest measurement was taken on 87 males using the procedures using the 90/90 test for hamstring flexibility described. While 87 subjects were measured, 75 males met the criteria that had been established for the study. The subjects were randomly assigned to one of three groups.

The control group consisted of 24 subjects and was measured and then later re-measured. The length of time between the two measurements of the control group was similar to those in the study group. The subjects in the control group performed no stretching before being remeasured.

The eccentric training group (n=25) was measured then performed full range of motion eccentric training for the hamstring muscles. The subject lay supine with the left lower extremity fully extended. A 3 foot (0.91 m) piece of

black theraband was held by the ends in each hand with the mid-section of the band wrapped around the right heel. The exercise started with the right knee locked in full extension and the hip in 0 degrees of extension. (Figure 2) The subject then pulled the hip into full flexion by pulling on the ends of the band with the arms. (Figure 3) The subject was to stop when he felt a gentle stretch.



Figure 1. The 90/90 test for measuring hamstring flexibility.

The position where the subject felt the gentle stretch was defined as full hip flexion. As the subject pulled the leg into hip flexion he was to resist the flexion motion by eccentrically contracting the hamstring muscles. The subject gave enough resistance to slow the hip flexion moment to take five seconds to complete. The eccentric activity was performed six times for a total stretch time of 30 seconds.

The static stretch group (n=26) performed a single 30 second static stretch using methods described by Bandy et al.^{1,15} The subject performed the hamstring stretch by standing erect with the left foot on the ground, toes pointed forward. (Figure 4) The heel of the right foot was on the seat of a chair or on a box. The subject's toes on the right lower extremity were pointed toward the ceiling. The subject then flexed forward at the hips, while maintaining a neutral spine. The subject was instructed to keep the right knee fully extended. The subject flexed forward at the hips until a gentle stretch was felt in the posterior thigh. The position of stretch was held for 30 seconds.

Data Analysis

Means (and standard deviation) for all groups and all measurements were calculated. A 3 (group) x 2 (test) analysis of variance (ANOVA) with repeated measures on one variable (test) was used to analyze the data. Since an interaction was found, appropriate post hoc tests were performed to interpret the findings and are described in the results section. An alpha level of $p < .05$ was considered appropriate for the level of significance.

RESULTS

Seventy-five male subjects, with mean age of 17.22 years ($SD = 1.30$), completed all requirements for this study. Twenty-four subjects, with a mean age of 17.18 years ($SD = 1.84$) served the control group. The static group consisted of 26 subjects with a mean age of 17.22 years ($SD = .76$) and statically stretched the hamstrings muscles. Twenty-five subjects comprised the eccentric group and had a mean age of 17.27 years ($SD = 0.96$). The mean values for the pretest and post-test measurements of the control group for the degrees of knee extension were 31.42 degrees ($SD = 9.97$) and 32.50 degrees ($SD = 10.19$), respectively. The ICC (3,2) value calculated for pretest-post-test knee extension data of the control group was .95.

The Table presents the means for pretest and posttest measurements and gain scores for each group. Results of the two-way ANOVA (group x test) indicated a significant difference for test ($df = 1,72$; $F = 59.16$; $p < .05$), group ($df = 2,72$; $F = 1.034$; $p < .05$) and interaction ($df = 2,72$; $F = 25.59$; $p < .05$).

In order to interpret the group x test significant interaction, three follow-up statistical analyses were performed. First, three dependent t tests were calculated on the pretest to posttest change for each group. Using a Bonferroni correction to avoid inflation of the alpha level due to the use of multiple t tests, the alpha level was adjusted to $p < .015$. The dependant t tests indicated significant increases in hamstring flexibility in the group statically stretching ($df = 25$; $t = 5.66$; $p < .015$) and the eccentric group ($df = 24$; $t = 6.85$; $p < .015$), but no significant change in hamstring flexibility in the control group ($df = 23$; $t = 1.83$; $p > .015$).

Second, a one-way ANOVA was calculated to assess whether any significant differences existed in the pretest scores across the three groups. Results of these analyses indicated no significant difference ($df = 2,72$; $F = .47$; $p > .05$). A one-way ANOVA was calculated to assess if any difference existed across the posttest scores of the three groups. Results indicated a significant difference ($df = 2,72$; $F = 5.15$; $p < .05$). Tukey HSD post hoc analyses

indicated that the mean posttest score of the static group (mean = 25.77, $SD = 9.15$) was significantly different from the posttest score for the control group (mean = 32.50, $SD = 10.19$). Also, the posttest score for the eccentric group (mean = 24.12, $SD = 9.66$) was significantly different from the posttest score for the control group. The static and eccentric groups did not differ from each other.

Finally, in an attempt to summarize the data, an additional analysis using a one-way ANOVA on gain scores was calculated, revealing a significant difference between groups ($df = 2$; $F = 25.585$; $p < .05$). Post hoc analysis using a

Tukey HSD test indicated a significant difference between the gain in the static stretch group (mean = 5.50, $SD = 4.50$) and the control group (mean = -1.08, $SD = 2.90$), and the eccentric group (mean = 9.48, $SD = 6.92$) and the control group. Finally, the eccentric group showed a significantly greater gain than the static stretch group.

DISCUSSION

The groups performing one bout of static stretching and one bout of eccentric training showed significantly greater gains in flexibility than the control group. The group performing one bout of eccentric training showed a significantly greater gain in flexibility than the static stretch group. To date, this is the only study to compare



Figure 2. Above, eccentric training, initial position. Below, final position of full hip flexion.



the immediate effects of one bout of eccentric training on changes in muscle flexibility. The results support the theory that the immediate effect of performing eccentric training through a full range of motion is an increase in muscle flexibility.

Eccentric training has been shown to improve flexibility not only from one bout of training as in this study, but also over a six week training program.¹⁶ The gains achieved by a six week program of static stretching and a six week program of eccentric training were very similar. Static stretching gained 12.04° and eccentric training gained 12.79° over the six week training program.

Comparing the gains made over six weeks with the gains made with one bout of stretching or training, the gains were less with the single bout of training or stretching. While the gains were less with only one bout of activity, the gains were still significant when compared with a control.

No studies to date have examined the use of eccentric training to reduce injury rates, but the SAID (Specific Adaptation to Imposed Demand) principle states that a muscle will adapt to the imposed demands.¹⁸ If the muscle adapts to the imposed demand of eccentrically training, theoretically, injury rates would be lower since most injuries occur during the eccentric phase of activity.



Figure 3. Static stretching position.

Strength gains from eccentrically training a muscle would, theoretically, also improve performance. The need to use a resistance band does make eccentric training more difficult than static stretching, but the author of this study believes the benefits achieved outweigh the added complexity of using resistance bands.

Important clinical implications exist for eccentric training through a full range of motion. In many cases, the goal for clinicians and patients is a restoration of normal functional motion. Normal motion requires the patient to have the flexibility and the strength to perform the movement. Strengthening through a full range of

motion will increase the likelihood that the patient will not only maintain the range achieved but will help ensure that the patient is able to use the range functionally. Eccentrically training through a full range of motion, theoretically, will improve the functional ability of the extremity by improving not only the flexibility but also the strength in that range.

A patient with weakness around a particular joint may not move the joint through a full range and structures around the area will often shorten leaving the patient with limited mobility. While static stretching has been proven to improve flexibility, the ability of static stretching to strengthen through and entire range of motion is

Table. Mean and standard deviation scores (in degrees) for pretest, posttest, and gain scores (in degrees) of knee flexion for each level of group.

	Group					
	Control (n = 24)		Static (n = 26)		Eccentric (n = 25)	
	\bar{x}	SD	\bar{x}	SD	\bar{x}	SD
Pretest	31.42	9.97	31.27	8.70	33.60	9.89
Posttest	32.50	10.19	25.77	9.15	24.12	9.66
Gain (difference)	-1.08	2.90	5.50	4.50	9.48	6.92

doubtful. Eccentric training is strengthening the muscle by having it contract as it lengthens. A patient eccentrically training through a full range of motion will be gaining range of motion and strength at the same time, thus, making the activity more functional. This type of training could also save time by combining the strengthening and flexibility components into one activity.

More research is needed to determine if tangible gains can be made in strength, injury reduction, and performance enhancement through the use of eccentric training. In addition, future studies should address the effects of eccentric training on individuals across a diverse age group and include females.

CONCLUSION

In high school and college aged male athletes, hamstring flexibility gains made from one bout of eccentric training (as measured by hip flexion range of motion gains) were significantly better than the gains made by a static stretch group and a control group. This study provides evidence that when dealing with the immediate effects of stretching, flexibility programs may actually be enhanced by replacing static stretching with eccentric training.

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